

**National Aeronautics and Space Administration
Washington, DC**

NASA ADVISORY COUNCIL

Human Exploration and Operations Committee

November 4-5, 2015

**NASA Headquarters
Washington, DC**

MEETING MINUTES

Kenneth Bowersox, Chair

Bette Siegel, Executive Secretary

**Human Exploration and Operations Committee
NASA Headquarters
Washington, DC
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**MEETING MINUTES
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NASA ADVISORY COUNCIL
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Human Exploration and Operations Committee
MEETING
NASA Headquarters
Washington, DC 20546
November 4-5, 2015

Wednesday, November 4

Call to Order and Welcome

Dr. Bette Siegel, Executive Secretary for the NASA Advisory Council (NAC or Council) Human Exploration and Operations (HEO) Committee, called the session of the HEO Committee to order at 8:30 a.m. She announced that the meeting was a Federal Advisory Committee Act (FACA) meeting and, therefore, would be open to the public. Minutes would be taken and posted online, along with the presentations. There would be an opportunity for the public to make comments towards the end of the meeting, and she asked for any questions or comments to be held until that time.

Mr. Kenneth Bowersox, HEO Committee Chair, welcomed everyone. He noted that Council member Mr. Wayne Hale would be attending the meeting, and Mr. Richard Malow and Mr. James Voss would be attending via WebEx. Mr. Bowersox reported that an interest had been expressed at the Council's last meeting for additional interaction with the NASA Aerospace Safety Advisory Panel (ASAP). Mr. Bowersox attended the ASAP meeting recently held at NASA Johnson Space Center (JSC). The Committee and the ASAP would have an opportunity to meet later in the day for an informal lunch.

Mr. Bowersox stated that Dr. Steven Squyres, NAC chair, has requested that the Committee focus attention on the International Space Station (ISS) transition from NASA operations in the mid-2020s to ensure that NASA obtains everything it needs from the ISS before its funding is shifted to the private sector. Dr. Squyres has also requested that the Committee continuously examine the risk matrices for exploration technology innovation. Mr. Gregory Williams, Deputy Associate Administrator (AA), Human Exploration and Operations Directorate (HEOMD), added that the Council's Technology, Innovation, and Engineering (TI&E) Committee also would be watching the innovation risk matrices.

Status of the Human Exploration and Operations Mission Directorate

Mr. Bowersox introduced the first speaker, Mr. Gregory Williams, who briefed the Committee on the status of the HEOMD. Mr. Williams distributed a new HEOMD publication entitled "NASA's Journey to Mars." He discussed Astronaut Scott Kelly's one-year ISS mission. Mr. Kelly recently set the record for the longest duration American space mission on day 215. The mission has completed its first six months. The Twins Study contrasts Mr. Kelly with his brother, former Astronaut Mark Kelly. The objective is to examine next generation genomics solutions to mitigating crew health and performance risks. In response to a question from Dr. Pat Condon, Dr. Siegel explained that data from the study is being analyzed and results are not yet available. Mr. Bowersox commented that it would be a good subject for the Committee's Research Subcommittee.

Progress on the Asteroid Redirect Mission (ARM) was reviewed. Mr. Williams observed that more people have begun to find substantial value in the mission for demonstrating capabilities needed for exploration. He noted that the acquisition strategy for the Asteroid Redirect Robotic Mission (ARRM) has been completed. Asteroid 2008EV5 remains the reference target. A graphic was presented showing what an early mission in the Proving Ground of cislunar space might look like. Mr. Williams described Solar Electric Propulsion (SEP) risk reduction activities that have been completed at NASA Glenn Research Center. He presented a slide on asteroid capture system prototyping and testing being performed at NASA Langley Research Center and NASA Goddard Space Flight Center. He described the 7-Degree of Freedom (7-DOF) robot capture arm. Mr. Williams explained that there is a synergy between the ARM and satellite servicing technology. He presented a graphic on the Microspine Gripper being developed at the NASA Jet

Propulsion Laboratory (JPL). It uses 200 independent hooks to grip the surface. Prototypes have been completed and tested with surrogate asteroid material.

Mr. Williams provided an overview of the Mars Human Landing Site Study. Potential landing sites are being selected that would provide access to Exploration Zones, which are regions that contain multiple sites of scientific interest as well as satisfying engineering and human constraints for human exploration. The study leverages the Mars Reconnaissance Orbiter (MRO), which is operating beyond its design life. The study is a joint HEOMD and Science Mission Directorate (SMD) effort. A slide on Exploration Zone layout considerations was presented. In response to a question from Dr. Condon, Mr. Williams explained that areas where water is close to the surface are considered the most sensitive from a planetary protection perspective. Dr. Condon quipped that “we have to protect the wetlands.” Mr. Williams responded that if there are going to be humans on Mars, “we are going to wind up with us messing it up and it messing us up, and we are just going to have to learn to live with that.” Mr. Williams described a recent workshop at the Lunar Planetary Institute (LPI) on potential Exploration Zones for human missions to the surface of Mars. He explained that the largest unknown is how to use different sources of water, such as buried ice, hydrated minerals, and hydrated dunes, for *in situ* resource utilization (ISRU). He noted that the workshop included people from the mining community who have experience with subsurface mineral extraction. In response to a question from Dr. Condon, Dr. Siegel stated that she is the point of contact on planetary protection concerns for human exploration. She explained that the primary concern is microbes. On robotic missions, the equipment can be sterilized. Human areas of operation are considered “dirty zones.” Radiation is expected to kill most microbes on the surface of Mars. In response to a question from Mr. Robert Sieck, Dr. Siegel advised that standards are not yet under development. Mr. Bowersox stated that planetary protection has been discussed at the Council by the Science Committee chair.

Mr. Williams reviewed recent accomplishments in NASA’s Space Communications and Navigation (SCaN) Program. He presented a slide showing the missions expected to be supported by SCaN in Fiscal Year (FY) 2016. He reviewed the SCaN Technology Development Roadmap. Mr. Williams concluded his presentation with a discussion on Venture Class Launch Services (VCLS). Demonstration launches of CubeSats have been awarded to three providers: Firefly, Rocket Lab, and Virgin Galactic. The providers are responsible for nonrecurring development costs. Payments will be based on milestones. The Launch Services Program (LSP) will provide insight on launch vehicle design reviews. It is anticipated that the success of the awardees will enable new low-cost launch options for science missions.

Mr. Bowersox thanked Mr. Williams for his presentation.

Status of Exploration Systems Development

Mr. Bowersox introduced Mr. Bill Hill, Exploration Systems Development (ESD) Program Director at NASA Headquarters. Mr. Hill briefed the Committee on the status of the ESD Division. There will be a new look for the Space Launch System (SLS) stack because the foam will not be painted in order to save 600 pounds. He reviewed the Exploration Mission-1 (EM-1) Integrated Mission Milestone Summary Chart. There are three critical paths on the chart: Crew Module (CM), European Service Module (ESM), and Core Stage. Each program is working to a different schedule and all are making good progress toward a 2018 launch date.

Mr. Hill described accomplishments in the Orion program. He stated that the heatshield would be a block approach, rather than a monolithic heatshield. Mr. Joseph Cuzzupoli expressed concern that ESD was abandoning the Apollo ablator heatshield model and changing both material and contractor. He advised making the pieces smaller to prevent cracking. Mr. Hill responded that NASA maintains the ability to return to a monolithic heatshield. He added that the biggest challenge for the block approach is verifying the bonding of the blocks to the substructure.

Mr. Hill reviewed the status of the Launch Abort System (LAS) and the ESM. He presented a slide on the CM, discussed Orion and SLS avionics and software, and described upcoming milestones for the fairings. Mr. Hill presented charts showing recent SLS accomplishments and the status of Orion Stage Adapters (OSA), Launch Vehicle Stage Adapters (LVSA), and the Interim Cryogenic Propulsion Stage (ICPS). Mr. Hill discussed the Core Stage and the challenges on the Vertical Assembly Center (VAC). He reviewed the status of the Solid Rocket Boosters (SRBs) and upcoming milestones for the RS-25 engines. The next hot firing is scheduled for the second quarter in FY 2016. Mr. Hill presented a slide showing recent accomplishments in Ground Systems Development and Operations (GSDO). The Program has completed modifications on the Mobile Launcher base and tower structure at NASA Kennedy Space Center (KSC). Mr.

Hill commented that Vehicle Assembly Building (VAB) is being modified to have a multi-vehicle capability. Its platforms will be able to move up and down 20 feet.

Mr. Hill introduced Mr. Jerry Cook, Chief Engineer on the Cross-Program System Integration (CSI) Team (CPIT). Mr. Cook described recent CSI accomplishments. He discussed the Team's top technical issues and described the issues that have been closed recently. He noted that there are no current elevated interdependencies. Mr. Hill reviewed a chart on ESD's top concerns. He expressed concern over funding and explained that replanning would be necessary if funding remained at the Continuing Resolution (CR) level.

Ms. Shannon Bartell asked Mr. Cook to explain what gives him confidence that the integration effort is effective. Mr. Cook responded that he draws his confidence from open communication and transparencies across the programs. He added that the integration function continues to evolve. Mr. Cuzzupoli asked who is responsible for signing off on the independent verification of software. Mr. Hill responded that it is NASA. He added that NASA is going through the process of working out the Certificate of Flight Readiness (CoFR). Dr. Leroy Chiao inquired when NASA would fly a crew on Orion. Mr. Hill responded that there would be four crew on EM-2 in 2021. He added that the CM and complete life support system would not be flown on EM-1. Mr. Bowersox noted that EM-2 would go out to a lunar orbit and would be the first flight for the Exploration Upper Stage (EUS). He suggested that having a habitation module on the flight would help to buy down risk. Mr. Hill responded that NASA would not have the habitation capability for EM-2. He added that the risk is increased by exposure time in low-Earth orbit (LEO) due to micrometeoroid and orbital debris (MMOD). Mr. Malow observed that the budget profile is not adequate to support the work that remains to be done. He stated that a SLS would likely be needed for the Europa mission and that mission would have a lander. Mr. Hill responded that NASA is looking at a surge requirement for SLS. Mr. Michael Lopez-Alegria requested an update on the transition to the EUS. Mr. Hill responded that there is a need to evolve the EUS and that it may have to be deferred for a year if there are insufficient appropriations. In response to a question from Mr. Voss, Mr. Hill explained that all the vehicles needed for the Exploration Program are defined in the architecture.

Mr. Bowersox thanked Mr. Hill for his presentation.

Status of Advanced Exploration Systems

Mr. Bowersox introduced Mr. Jason Crusan, Director, Advanced Exploration Systems (AES) Division, HEOMD. Mr. Crusan explained that AES is engaged in a rapid development and testing of prototype systems and validation of operational concepts to reduce risk and cost of future exploration missions. AES had 572 civil servants and 162 contractors in FY15. Their work covers crew mobility systems; habitation systems; vehicle systems; foundational systems; robotic precursor activities; and strategic operations, integration, and studies. AES's goal for FY 2015 was to accomplish 80 percent of 72 milestones. Over 60 percent of the milestones had flight demonstration elements. Fifty-six milestones were accomplished, reflecting a 72 percent accomplishment rate.

Mr. Crusan reviewed a chart on the demand areas for Pioneering Space's steps on the journey to Mars. The missions shown on the chart are the ISS, cislunar short stay, cislunar long stay, cis-Mars robotic, orbital proving ground, and Mars operational. There are three categories of demand areas for those missions: transportation, staying healthy, and working in space and on Mars. Mr. Crusan described three Earth Reliant, near-term objectives: develop and validate exploration capabilities and in-space environment, long-duration human health evaluation, and commercial crew transportation. He reviewed a chart on Proving Ground objectives.

Mr. Crusan reviewed AES current activities and recent accomplishments. He described progress on ISRU, where the objective is to reduce logistical support from Earth by utilizing local resources to produce water, oxygen, propellants, and other consumables. The Resource Prospector is a robotic mission in formulation to prospect for ice and other volatiles in the polar regions of the Moon. The Mars Oxygen ISRU Experiment (MOXIE) is designed to demonstrate oxygen production from the Mars atmosphere on the Mars 2020 mission. Mr. Crusan presented a chart on habitation and explained that the objective is to develop a deep space habitat that will enable a crew to live on deep space missions lasting 1,100 days. The Bigelow Expendable Activity Module (BEAM) will demonstrate an inflatable habitat on the ISS. Its launch on SpaceX CRS-8 is planned at that time for January 2016. Next Space Technology Exploration Partnerships (NextSTEP) were described. They are commercial partnerships to develop concepts for cislunar habitats that are extensible to Mars transit habitats. NextSTEP Commercial Habitat Concept Study contracts have been

awarded to Bigelow Aerospace, Boeing, Lockheed Martin, and Orbital ATK. Current activities and recent accomplishments in developing autonomous systems and operations were reviewed. Mr. Crusan described the next generation Portable Life Support System (PLSS). He discussed the Z-Suit, an advanced spacesuit under development with improved mobility for surface exploration. In response to a question from Mr. Cuzzupoli, Mr. Crusan stated that there is a near-term need for in-space exploration suits and that from a technical perspective, NASA is ahead of where it needs to be for suit development that enables surface missions. The intention is to test the Z-Suit on the ISS before going to cislunar space. Mr. Bowersox noted that AES has the lead for future suit development and that ISS is responsible for current suits. In response to a question from Ms. Nancy Ann Budden, Mr. Crusan explained that the Z-Suit is a surface suit and that AES has been concentrating on modular interfaces. Ms. Budden queried whether the Z-Suit would have a heads-up display. Mr. Crusan responded that AES is looking at different display technologies including heads up displays. Ms. Budden recommended interfacing with the Department of Defense (DoD) for information on displays used by Special Operations.

Mr. Crusan discussed AES progress in environmental control and life support. The objective is to develop highly reliable life support systems that recycle air, water, and waste to reduce consumables. He discussed spacecraft fire safety. Saffire experiments will investigate large-scale flame propagation and multi-material flame propagation in microgravity. He described current activities and accomplishments in radiation safety. A chart was presented on developments in entry, descent, and landing (EDL). The objective is to develop the capability to land payloads over 18 metric tons on Mars for human missions. Mr. Cuzzupoli queried whether NASA has decided where to practice Mars landing systems. Mr. Crusan responded that NASA has not yet done so, nor has it yet decided on the scale to use for testing. In response to a question from Mr. Cuzzupoli, Mr. Crusan explained that a human-class Mars lander is in the concept stage and is not in development.

Mr. Crusan described current activities and accomplishments on in-space power and propulsion. NextSTEP is developing 100 kilowatt (kW) electric propulsion thrusters. A nuclear thermal propulsion project is being transferred from AES to the Space Technology Mission Directorate (STMD) to continue work on the development of fuel elements. He described activities in communications and discussed logistics reduction. A demonstration of 3-D printing of spare parts and tools is currently on the ISS. Genetically engineered bacteria are being researched to produce bionutrients to supplement the crew's diet. He discussed robotic precursor activities. The objective is to gather crucial data on environments, hazards, and the availability of resources at potential destinations to inform the design of exploration systems. Mr. Crusan described three concepts under consideration as EM-1 secondary payloads: the BioSentinel, the Lunar Flashlight, and the Near Earth Asteroid (NEA) Scout.

Mr. Crusan presented charts on AES major FY 2016 milestones and budget scenarios. He reviewed a chart summarizing recent NextSTEP contract awards. Twelve proposals have been selected, and AES will proceed to enter into fixed-price contracts using technical payment milestones. The contracts are intended to emphasize the contribution of corporate resources to a private-public partnership to achieve the program's goals and objectives. Mr. Cuzzupoli asked whether any of the contracts covered a cooling system for avionics. Mr. Crusan responded that they did not. In response to another question from Mr. Cuzzupoli, Mr. Crusan explained that the contractors contribute 50 percent of the program's cost, with some contributing more than that.

Mr. Bowersox thanked Mr. Crusan for his presentation.

Evolvable Mars Campaign

Mr. Crusan briefed the Committee on the Evolvable Mars Campaign (EMC). He explained that there are seven strategic principles for sustainable exploration:

- implementable in the near-term with the buying power of current budgets and in the longer term with budgets commensurate with economic growth;
- exploration enables science and science enables exploration, leveraging robotic expertise for human exploration of the solar system;
- application of high Technology Readiness Level (TRL) technologies for near term missions, while focusing sustained investments on technologies and capabilities to address challenges of future missions;

- near-term mission opportunities with a defined cadence of compelling and integrated human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
- opportunities for U.S. commercial business to further enhance the experience and business base;
- resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique major developments, with each mission leaving something behind to support subsequent missions; and
- substantial new international and commercial partnerships, leveraging the current ISS partnership while building new cooperative ventures.

Mr. Crusan reviewed a chart showing the history of beyond-LEO spaceflight architecture development. He contrasted design reference missions and design philosophy. He explained that the EMC is an ongoing series of architectural trade analyses that are being executed to define the capabilities and elements needed for a sustainable human presence on Mars. It builds from previous studies and ongoing assessments, and it provides a clear linkage of current investments, such as SLS and Orion, to future capability needs. He presented a graphic showing the EMC and its three domains: Earth Reliant, Proving Ground, and Earth Independent. Mr. Crusan explained that the EMC goal is to define a pioneering strategy and operational capabilities that can extend and sustain human presence in the solar system, including a human journey to explore the Mars system starting in the mid-2030s. He presented a graphic demonstrating the breadth and depth required for EMC assessment capability. He reviewed a chart on the NASA Technology Roadmaps and Investment Plan. Mr. Cuzzupoli asked how many “old-timers” helped to develop the maps. Mr. Crusan responded that many had been brought in on consulting contracts and via informal sessions.

Mr. Crusan discussed the role played by System Maturation Teams (SMTs). He explained that SMTs comprise subject matter experts from across the Agency who have been involved in maturing systems and advancing technology readiness for NASA. The SMTs are defining performance parameters and goals for 15 capabilities, developing maturation plans and roadmaps for identified performance gaps, specifying interfaces between the various capabilities, and ensuring that the capabilities mature and integrate to enable future pioneering missions. The SMTs work closely with the EMC to coordinate capability needs and gaps. Mr. Crusan reviewed several charts showing how SMTs help influence investment strategy and identify commonalities. He described the advantages and disadvantages of commonalities. He reviewed charts on the EMC small-habitat commonality scope. Mr. Crusan explained that commonality is intentional, must be initiated at the front-end, and has to be controlled by management. He presented charts on maximizing commonality across the small habitats for the Mars Ascent Vehicle (MAV), Mars-vicinity crew taxi, Mars-Moon exploration vehicle, and initial short-duration deep-space habitation.

Mr. Crusan discussed a chart on the Proving Ground top-level goals. Dr. Condon observed that multiple parallel paths are being pursued. Mr. Crusan explained that multiple paths can be afforded at this time because they are only concepts. Mr. Lon Levin asked how costs are shared with other nations. Mr. Crusan responded that each nation pays for its own contribution. In response to a question from Mr. Malow, Mr. Crusan explained that new ideas from JPL’s presentation on a Mars landing are folded into the EMC campaign and that JPL is on the EMC team and their results were being folded into the overall analysis efforts. Mr. Crusan concluded his presentation with a chart on EMC FY 2016 plans.

Mr. Bowersox thanked Mr. Crusan for his presentation.

Committee Discussion

Mr. Bowersox reviewed a chart on topics with potential for findings and recommendations. He suggested that the Committee consider identifying its top concerns and presenting that list to the NAC at each meeting. He explained that this practice had been recommended by Council member Mr. Thomas Young. Mr. Bowersox described special topics that could be considered at future HEO Committee meetings. One special topic would be coordination with the ASAP. Mr. Bowersox commented that the ASAP could be trusted to provide sufficient coverage on safety issues and that some Committee overlap with the ASAP would be acceptable. He presented charts on the Committee’s proposed work plans for its future meetings. He commented that it would be helpful to hear from the transition teams for the next administration.

Ms. Bartell asked whether there was a record on the number of Committee recommendations for the Administrator that had been approved by the NAC. Mr. Bowersox responded that the NAC had approved almost 100 percent of the

Committee's findings for the HEOMD AA, Mr. William Gerstenmaier, and approximately 65 percent of the Committee's findings and recommendations for the Administrator.

Mr. Lopez-Alegria commented that the most valuable part of the meetings have been the non-FACA fact-finding sessions with Mr. Gerstenmaier. He suggested that those be maintained and expanded. He observed that there is a lot of effort to have everyone show up for Committee meetings, with too little result to show for that effort. Ms. Budden agreed with Mr. Lopez-Alegria and stated that the Committee's most important role is to provide advice to Mr. Gerstenmaier. Dr. David Longnecker asserted that the Committee's approval record was as good as other NAC committees. He suggested reaching out to NASA's new Deputy Administrator, Ms. Dava Newman, for her opinion on how the Committee could communicate more effectively. Dr. Longnecker reported that, for the last transition, each NAC committee had developed a list of issues for each of the transition teams prior to the election to inform them about what the committees thought was important. In his opinion, he felt that the effort was not successful. Dr. Condon stated that he agreed with Mr. Lopez-Alegria. He observed that much of the Committee's value to NASA occurs in the informal conversations. He noted that a DoD Inspector General (IG) study had found that only two percent of the Defense Science Board's recommendations had been implemented.

Mr. James Odom stated that using a list of top concerns was a subtle way to tell the system that the Committee is worried about something but not ready to make a recommendation. Mr. Sieck commented that advisory panels never tell NASA something that NASA does not already know; they provide a tangible benefit, however, in reinforcing something that NASA wants to do. Mr. Cuzzupoli asserted that the NASA/congressional system is broken and that now was not the time to fix it. He added that the Committee should address problems immediately and move on. He expressed concern that NASA did not have a program master plan to get to a destination. Mr. Voss suggested that the Committee be provided with "pre-meeting homework" and be given white papers on topics that the Committee was going to be hearing about. Mr. Hale advised that an important topic would be how to make NASA more efficient in getting systems developed. He asserted that people trying to develop new systems are "drowning in process and regulations." Ms. Bartell cited NASA Procedural Requirement (NPR) 7120 as a primary example.

Adjournment

Dr. Siegel adjourned the Committee meeting for the day at 3:30 p.m.

Thursday, November 5, 2015

Call to Order, Welcome and Opening Remarks

Dr. Siegel called the HEO Committee meeting to order at 9:30 a.m. and welcomed everyone back. She announced that it would be a public meeting, and that minutes would be taken and posted with all presentations. She introduced Mr. Bowersox.

Human Space Flight Transition from International Space Station to Cislunar Space

Mr. Bowersox introduced Mr. Sam Scimemi, Director, ISS, NASA Headquarters. Mr. Scimemi briefed the Committee on transitioning human space flight (HSF) from the ISS to cislunar space. He explained that this was moving from Earth Reliant to the Proving Ground. He presented a graphic showing the phases involved for the Journey to Mars. The Earth Reliant phase would have missions lasting from 6 to 12 months and a return to Earth requiring hours. The Proving Ground would have missions lasting from 1 to 12 months and a return to Earth requiring days. The Earth Independent phase would have missions lasting from two to three years and require months to return to Earth.

Mr. Scimemi described recent meetings held with NASA's international partners on how they perceive the journey to Mars. He noted that different nations have different perspectives on what they want to accomplish. Some nations view cislunar space as a robotic research objective and not a proving ground for HSF. Some countries may not want to invest in HSF, while others want to lead in HSF. He asserted that NASA has to balance its internal needs with what industry and international partners want to accomplish. That requires an intelligent conversation with all the stakeholders.

Mr. Scimemi stated that NASA's goal is to be Mars-ready at the end of the 2020s. He described what needs to be learned in order to be Earth independent. He explained that learning how to be Earth independent starts with short duration habitation and ends with long duration habitation. Mr. Scimemi introduced Ms. Robyn Gatens, Deputy Director, ISS, NASA Headquarters. Ms. Gatens reviewed a chart on habitation systems objectives. She discussed the cislunar goals for systems for life support, environmental monitoring, crew health, extra-vehicular activity (EVA), fire protection, and radiation protection. Mr. Scimemi stated that maturing those systems would be more difficult than building the habitation module.

Mr. Scimemi discussed human health and performance research in the transition from ISS to cislunar space. He reviewed a chart on ISS goals for space exploration and cislunar space goals. Potential research objectives include the origins of the universe; the search for life; monitoring the Earth, Sun, and Moon environs; and basic research for exploration and astrophysics. He explained that NASA would use a one-year mission in cislunar lunar space to validate things learned on the ISS and prove that NASA can go to Mars. When that one-year mission is completed, NASA would be comfortable going to Mars.

Mr. Bowersox asked whether there was a plan for the ISS transition. Mr. Scimemi responded that there is a rough schedule and that a complete plan would be developed next year, provided adequate funding is available.

Mr. Bowersox thanked Mr. Scimemi for his presentation.

Status of International Space Station

Mr. Scimemi briefed the Committee on the status of the ISS. He reviewed the ISS Flight Plan and its port utilization schedule. He discussed expected accomplishments and objectives for Increments 45 and 46. The Increment 45 crew was described. Mr. Scimemi noted that the crew would be responsible for working with six vehicles. He added that there would be nine people on board the ISS for a week. In response to a question from Mr. Cuzzupoli, Mr. Scimemi explained that three Soyuz spacecraft were docked to the ISS and available if the crew on board had to be evacuated.

Mr. Scimemi discussed the ISS reconfiguration status. The goal is to establish two new docking ports and two new berthing ports on the U.S. Orbital Segment (USOS). A chart describing EVAs was presented. Mr. Scimemi noted that only one planned task could not be completed. Dr. Longnecker asked whether there would be an update on the frequency of EVAs. Mr. Scimemi responded that the issue is complicated and recommended that it be handled as a special topic. Mr. Scimemi reviewed a chart on Increment 45/46 crew-time utilization. The plan was to obtain 35 hours per week. The actual average was 35.25 hours per week. Mr. Scimemi reviewed a chart on the ISS research statistics from Increments 45 and 46. Over 800 investigators were represented. There were 261 investigations, including 49 new investigations, and over 1200 scientific results publications. Mr. Scimemi presented a slide showing the complete Increment 45 and 46 research complement.

Mr. Scimemi discussed the status of consumables on board the ISS. He presented charts showing the total consumables on the ISS and on the USOS. Mr. Scimemi noted that the consumable reserve margin had been recovered after the series of launch failures in the past year. Mr. Bowersox commented that the last Japanese H-II Transfer Vehicle (HTV)-5 cargo spacecraft had been loaded with science rather than supplies because the consumable reserve margin had been recovered. Mr. Scimemi reviewed charts on new and existing ISS vehicle issues. He noted that a high Total Organic Carbon (TOC) status had indicated that the Water Processor Assembly (WPA) Multifiltration (MF) Beds were saturated. A new compound, monomethylsilanetriol (MMST) was found in return-to-ground samples. An initial evaluation indicated that MMST is very similar to dimethylsilanediol (DMSD), which had been identified previously as

a problematic organic contaminant aboard the ISS. WPA conductivity increase is being managed through reprocess cycles. TOC readings are now under detectable limits.

Mr. Scimemi discussed ISS cargo resupply missions. The HTV-5 mission berthed with the ISS on August 24, 2015. Orbital ATK has contracted with United Launch Alliance (ULA) for an Atlas V launch of the Orbital (Orb)-4 mission with the Cygnus spacecraft. It will be the first use of the Atlas V with the Cygnus spacecraft. Mr. Cuzzupoli observed that Cygnus will be going directly to the ISS the first time that it flies on an Atlas 5. Mr. Scimemi responded that the Cygnus was designed to be flown on multiple vehicles. The Orb-5 mission status was reviewed. Orb-6 will be the first enhanced Cygnus on the upgraded Antares launch vehicle and will be launched from the Wallops Flight Facility (WFF). Mr. Scimemi reviewed the SpaceX-8 mission. He updated the Committee on the status of the Dragon capsule and the Falcon 9 launch vehicle. He described the SpaceX-9 mission status. He also described the 62P Progress-MS, which is an improved variant of the Progress vehicle.

Mr. Bowersox reported that Dr. Squyres has requested a special emphasis on ISS utilization at the next NAC meeting at JSC. In response to a question from Mr. Cuzzupoli, Mr. Scimemi stated that despite recent moves, the management staff level for the ISS is relatively healthy.

Mr. Bowersox thanked Mr. Scimemi for his presentation.

Status of Commercial Crew

Mr. Bowersox introduced Ms. Kathy Lueders, Program Manager, Commercial Crew Program (CCP). She briefed the Committee on the Program's status. Mr. Lueders provided an overview on how certification for each commercial crew contractor would be handled. She explained that CCP Certification and CoFR strive to achieve a balance of insight and oversight appropriate for shared government and industry accountability in establishing a safe, reliable, and cost-effective Commercial Transportation System (CTS). The industry partner is responsible for the design, development, test, and evaluation, culminating in its certification assertion of its CTS to transport crews to and from the ISS. The CCP is accountable for ensuring compliance to CCP's HSF requirements through evaluation and approval of the contractor's compliance evidence and execution of NASA's insight into the contractor solution in accordance with a risk-based insight approach implemented under a shared assurance model. The shared accountability balance acknowledges industry's safety obligations in owning and operating CTS services for both government and private sectors. It also acknowledges NASA's obligations for assuring crew safety and mission success for NASA missions, relying on a shared assurance and risk-based strategy.

Ms. Lueders described the CCP model for allocating responsibilities between NASA and industry. The CCP model, by design, allocates greater accountability to industry. There are three activities for NASA's design certification: establish requirements, manage development risk, and establish a certification baseline. The activities for NASA's flight readiness certification are to validate the baseline certification and assess mission readiness. NASA CCP performs a risk-based approach to both oversight and insight activities. Mr. Sieck asked how NASA employees have adjusted to the cultural change from oversight to insight. Ms. Lueders responded that that is something they continue to work on. She added that NASA is coming from a culture of telling people what to do, to letting people come up with their own solutions. Making them a partner helps that discussion. She noted that NASA's teams have been trained to ask whether there are multiple solutions. Mr. Malow asked whether the culture change affects the time to get to launch. Mr. Lueders responded that NASA is trying to avoid having that effect, that it is tracked all the time, and that it is one of the highest risk areas. In response to a question from Ms. Bartell, Ms. Lueders explained that NASA's technical authorities are included in the strategies and agreements being made with the commercial partners, are part of the program plan for closure, and are integrated in the risk buyoff along the way. Mr. Cuzzupoli stated that what is most important are the people, that he trusts Ms. Lueders, and that he knows it is going to work for NASA. He noted a concern that he does not know who would be taking her place.

Ms. Lueders explained that NASA's certification is implemented through a certification plan, requirements verification and validation, phased safety reviews and hazard reports, insight and audits, and approval of key milestone reviews and deliverables. She noted that safety reviews are a painful process for the contractors and that hazard reports are a key document. Ms. Lueders explained that NASA CTS certification is the approval of the commercial provider's evidence of (i) compliance with the Crew Transportation Technical Management Processes, (ii) adherence to the Crew

Transportation Technical Standards and Design Evaluation and the Crew Transportation Operation Standards, and (iii) compliance with the ISS Crew Transportation and Services Requirements (CCT-REQ-1130) and ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD) (SSP 50808). The CCP and the ISS Program will approve compliance with 1130. The ISS Program will approve compliance with 50808. Dr. Condon asked whether any role is played by the Astronaut Office. Ms. Lueders responded that there is Flight Operations Directorate membership on all the boards and that they are a key component in the insight process. Dr. Condon asked whether they have “go/no go” authority. Ms. Lueders responded that they are part of the board structure, part of the flight readiness approval process, and an integral part of the team. She added that the contract includes a joint test-team approach where NASA’s crew members work with the contractor. Ms. Lueders explained that the Human Rating Certification Package in NPR 8705.2B has also been flowed down and is included in the certification requirements. She presented a chart on the Commercial Crew Transportation System (CCTS) documentation flow down. She reviewed a purpose and mapping chart on CCT-REQ-1130. She explained that CCT-REQ-1130 is the requirement set for the entire CTS from launch through landing while independent of the ISS. The chart illustrates how NPR 8705.2B Human-Rating Technical Requirements are made applicable to CCT-REQ-1130. In response to a question from Mr. Cuzzupoli, Ms. Lueders responded that NASA’s international partners have been briefed on the process.

Ms. Lueders discussed the commercial partner certification assertion. She noted that the CCP certification builds upon the requirements levied on the Commercial Crew Transportation Capability (CCtCap) contract. The CCP is responsible for substantiating the commercial provider’s certification assertions. She described how the requirements interrelate. SSP 50808 is an overarching interface requirements document for the ISS. It contains requirements that are necessary for docking or berthing to the ISS. All standards for SSP 50808 and CCT-REQ-1130 have been reviewed and are the same or complimentary. Variances can be submitted for either. All variances are reviewed and approved through the appropriate Program Board structure. Ms. Lueders explained that standards identified by the words “meet” must be followed completely with no deviation or alternative proposal. Standards that use the language “meet the intent of” can be met by following the standard or by proposing alternative standards that meet or exceed the requirement.

Ms. Lueders reviewed a chart on the verification development flow. She discussed NASA Phased Safety Review requirements. Those requirements ensure that there are adequate controls for catastrophic hazards. The CCtCap partners must derive their own detailed requirements for those controls. Hazards that can affect the ISS are reviewed jointly by the ISS Visiting Vehicle Safety Review Panel (SRP) and the CCP Safety Technical Review Board (STRB). The scope of safety reviews is to determine, given a commercial provider’s solution, that analysis was conducted to the appropriate level to surface key risks in the design and whether risks exist beyond the requirements established for certification. Results are intended to inform the design and program reviews and establish the level of acceptable risk for the system. Any requirement non-compliances or accepted risks outside the STRB are forwarded to the CCP/ISS Program Boards for acceptance. Ms. Lueders stated that CCP adopted the ISS model for the base safety review process. She added that CCP did not put performance requirements on the launch vehicles. Those are driven by fault-tolerance requirements. She noted that that is a strategy that has never been done before and was new to both contractors. In response to a question from Mr. Cuzzupoli, Ms. Lueders responded that both contractors are subject to the same requirement for abort plans and have different ways of satisfying the requirement. Mr. Lopez-Alegria asked who the flight director would be during the rendezvous phase. Ms. Lueders answered that ISS FD will lead operations during ISS rendezvous and docked phases which are “joint operations” phases. CCP vehicle Flight Directors will be lead for the CCP vehicles operations during all other phases.

Ms. Lueders described the mandatory interim milestones to review and approve the contractor’s progress toward certification. The interim milestones are Certification Baseline Review (CBR), ISS Design Certification Review (DCR), Flight Test Readiness Review (FTRR), Operations Readiness Review (ORR), and Certification Review. Ms. Lueders explained that CTS certification is the approval of the commercial provider’s evidence that all tests, analyses, verification, and validation proves that the baseline design meets the reference configuration. CTS certification will be incrementally approved through oversight and risk-based insight in parallel to CCtCap certification-related milestones. CTS CoFR refers to the NASA endorsement that compares and validates the hardware built and any issues uncovered to the reference certified configuration. CTS CoFR will be incrementally approved through oversight and risk-based insight in parallel to CCtCap flight readiness milestones.

Ms. Lueders explained that the HEOMD AA is the ultimate approval authority for both certification and CoFR. In response to a question from Mr. Bowersox, Ms. Lueders stated that the HEOMD AA would be responsible for signing

the CoFR. At Mr. Bowersox's request, Ms. Lueders confirmed that every flight would have a CoFR. The contractors will certify that the requirements have been met and that they are delivering a certified flight system. She added that there may be risks that have to be accepted. In response to a question from Mr. Bowersox, Ms. Lueders stated that the language for the CoFR is being developed. She noted that the contractors would not be accepting the risk for putting the crew on the vehicle. NASA acknowledges that there is always risk in space flight and that the commercial providers cannot accept the risk for NASA crew's lives. The provider will say that it is delivering the system and it is "ready to go," and NASA will say "yes, you are ready and we are willing to put crew on the flight." NASA accepts the risk from the crew's perspective. Mr. Bowersox emphasized the important symbolism of a final signature on a piece of paper stating "Put the crew on, I think the vehicle is good enough for them to fly on."

Ms. Lueders concluded her presentation by reporting that both commercial providers are meeting contractual milestones, progressing through Phase II Safety Reviews, working detailed verification and validation planning, maturing their detailed designs, providing increased insight opportunities for the NASA team, have advanced beyond paper products, and are building and testing hardware.

Mr. Bowersox thanked Ms. Lueders for her presentation.

SpaceX Commercial Crew

Mr. Bowersox introduced Mr. Benjamin Reed, SpaceX Commercial Crew Program Director. Mr. Reed provided an overview of SpaceX for the Committee. SpaceX designs, manufactures, and launches rockets and spacecraft. It was founded in 2002 with the ultimate goal of enabling people to live on other planets. It is the world's fastest-growing launch provider and has over 4000 employees. He presented a slide showing three SpaceX vehicles: Falcon 9, Falcon Heavy, and Dragon. Mr. Reed noted that Falcon 9 has had seven successful Dragon flights to the ISS and that the Falcon Heavy can develop 4 million pounds of thrust.

Mr. Reed stated that SpaceX and NASA have developed a strong partnership through the Commercial Crew and Cargo programs. There are many details and relationship building is essential. He explained that his job is to serve the people and those relationships and to make sure that the people communicate at all levels. He noted that NASA is provided an unprecedented level of insight and access. There are over 30 on-going forums where SpaceX designers are talking to NASA regularly.

Mr. Reed provided an overview of the SpaceX commercial crew program. He stated that SpaceX is developing a safe, reliable and complete CTS. He explained that the key to the mission is reusability and that focusing on reusability leads to safety, consistency, and reliability. The system includes the Dragon crew vehicle, the Falcon 9 launch vehicle, the ground launch system, and all operations necessary for crew, launch, mission, ground, and recovery. Mr. Reed noted that Dragon had been flown in its first incarnation as a cargo vehicle. Dragon 2, the next iteration, will be for crew. Upcoming flights are Demo-1 to ISS, an in-flight abort test, Demo-2 to ISS, and up to six post-certification missions (PCMs). Demo-1 will be uncrewed, fully autonomous, and controlled from the ground. Demo-2 will have two NASA crew on board. In response to a question from Dr. Condon, Mr. Reed stated that the projected date for Demo-2 is March 2017.

Mr. Reed described the crew system architecture. The spacecraft segment is the Dragon crew vehicle, which can carry four to seven crew. A video was presented showing the crew vehicle interior. The launch abort system is internally integrated into Dragon. A video was presented showing a water landing with four parachutes. The launch system is the Falcon 9. It uses Merlin engines and has landing legs that are stowed during ascent. The ground system uses Launch Complex (LC)-39A at NASA KSC. Mr. Reed presented a chart showing program milestones and certifications. He described a successful May 2015 pad abort test. The test validated key predictions for ensuring safe transport of astronauts to the ISS. In response to a question from Mr. Bowersox, Mr. Reed stated that the biggest concern is the sheer volume of work and making sure that each group is moving along and making progress. In order to ensure that pace is maintained with NASA, SpaceX has worked hard to understand how NASA is organized. In response to a question from Mr. Cuzzupoli, Mr. Reed stated that Mr. Hans Koenigsmann is SpaceX's Chief Engineer.

Mr. Bowersox thanked Mr. Reed for his presentation.

Boeing Commercial Crew

Mr. Bowersox introduced Mr. John Mulholland, Program Manager, Boeing Commercial Programs, who briefed the Committee on Boeing's commercial crew program. Mr. Mulholland gave an overview of the program. The Atlas V launch vehicle was selected because it is a proven launch vehicle. It has had 58 successful launches and significantly reduces system risk. The Starliner Spacecraft uses flight proven systems and has successfully completed Critical Design Review (CDR). In response to a question from Mr. Bowersox, Mr. Mulholland explained that the heatshield will be a one-piece composite structure, hand laid-up. Mr. Mulholland explained that integration, testing, and quality processes are based on Space Shuttle and ISS approaches. He presented a graphic illustrating the concept of operations from launch to landing recovery. He described the spacecraft segment features. It provides seating for up to five crew. A clamshell crew module design allows easy hardware installation. He described the launch segment and the ground segment features.

Mr. Mulholland reviewed the Boeing commercial crew campaign plans for 2015, 2016, and 2017. In 2017, Boeing will conduct the pad abort test, the first uncrewed flight, the first crewed flight, and certification. He described the integration and testing for the campaign. He reviewed charts on key focus areas. Mr. Mulholland noted that targeted

investment in component development testing is paying dividends towards retiring substantial risks to qualification. He discussed the Boeing Starliner verification, test, and certification process. He explained that Boeing's verification methods and activities directly trace to NASA CCT-REQ-1130 and SSP 50808. The vehicle test program is shaped to provide direct verification of design and hazard requirements and supply the data from testing to correlate the design analytical models. A one-time Certification of Design (CoD) is extrapolated and reviewed to execute a CoFR for each mission and on-orbit flight test. Mr. Mulholland presented a chart on the verification and validation (V&V) status. He stated that the Boeing V&V plan is in the NASA approval cycle. The ISS Joint Integrated Test Verification Plan (JITVP) is at NASA for vetting. With V&V Plan and JITVP approval, Boeing will have agreement with the full set of verification requirements.

Mr. Mulholland described Boeing's Master Test Plan. It defines and baselines the CCTS program test architecture. He discussed the certification approach. Certification is guided by NASA's Crew Transportation Technical Management Processes and NASA's CTS Certification Plan. CCTS certification is accomplished using a four-step approach:

- Step 1: Define requirements baseline.
- Step 2: Compile evidence needed to develop certification data packages.
- Step 3: Complete certification assessment reports (CARs) and checklists documenting the module, segment, and system endorsements in support of CCTS certification review and approval.
- Step 4: Complete integration with and support of CCP and ISS boards gaining NASA's approval.

Mr. Mulholland explained that certification takes place at the component, module, segment, and system levels. CoD ensures that the verification of CCTS requirements are aligned to NASA CCT-REQ-1130, SSP 50808, and CCTS design specification requirements, and that vehicle configuration has been properly verified. CoFR ensures that the V&V is complete, liens and constraints have been dispositioned with an acceptable level of risk to commit to flight, and mission specific loads are verified and ready.

Mr. Bowersox asked whether there had been any new challenges working with NASA. Mr. Mulholland responded that nothing unexpected had occurred. He noted that the cultures of NASA and Boeing had grown up together. He added that it is necessary to operate at pace on a fixed-price contract, which has been a learning experience. Mr. Bowersox asked whether there have been any problems getting decisions from NASA at the right pace. Mr. Mulholland responded that Boeing has worked at pace to get the product delivered and that Ms. Lueder's challenge is keeping pace with two partners. He stated "when it is time for somebody to sign their name is when it gets challenging." Mr. Cuzzupoli commended Boeing for testing on materials in advance.

Mr. Bowersox thanked Mr. Mulholland for his presentation.

Mr. Bowersox commented that the way Boeing and SpaceX do their business is going to affect how NASA does business in the future when sending crew to Mars. He wished both companies "all the success in the world."

Public Comments

An opportunity was given for the public to make comments. There were no comments.

Committee Discussion, Findings, and Recommendations

Mr. Bowersox asked whether there were any findings or recommendations that Committee members wished to suggest. There were none.

The Committee continued to work on identifying a set of top concerns. The following top concerns, in no order of priority, were approved by consensus:

- need for U.S.-operated LEO crew and cargo transportation,
- low level of definition for Mars Exploration architecture impedes effort to generate support,
- cost impact of NASA processes, and
- low SLS and Orion launch rates

The Committee also worked to identify additional concerns for discussion. The following concerns in no order of priority, were discussed as potential areas of concern.

- cumulative effect of content reductions due to cost pressures in SLS and Orion Programs,
- fragility of SLS and Orion programs due to program content,
- imbalance between objectives and funding in SLS and Orion,
- effects of less than requested funding for commercial crew,
- conflicting direction for human exploration programs from legislative and executive branches,
- split support for human exploration programs,
- communication of program objectives and accomplishments to build and unify support,
- transition planning for ISS,
- lack of acceptance of current capability-driven approach,
- lack of a formal Mars (Human Exploration) Program, and
- communication of program objectives and accomplishments to build and unify support

There were additional observations, for potentially presenting to the Council

- Good progress for Commercial Crew Program Certification
 - Reasonable plan for certification/vehicle flight readiness
- Progress made in the capability development area
- Capability requirements for future exploration being used to guide ISS transition
 - Reasonable progress on ISS transition plans-work still underway
- Good progress for SLS, Orion, and ground systems-building momentum
- People are working hard to accomplish the work ahead of them
- Observe progress in formal integration of SLS, GSDO and Orion
- Current capability based approach for human exploration is reasonable considering current political and economic environment

Ms. Budden stated that Mr. Gerstenmaier had requested the Committee's comments on the Journey to Mars publication. Dr. Siegel advised that a public meeting would need to be held and noticed in the Federal Register if the comments were to come from the Committee. Mr. Bowersox requested Committee members to send him their comments by the evening of November 16, 2016. Mr. Cuzzupoli stated that "the document is boring." He advised that it should show the hardware currently being built and a timeline for getting to Mars. He added "I couldn't sell this thing to anybody. We are not telling the story on how we are getting to Mars."

Mr. Bowersox commented that good progress is being made with the CCP and that the certification process is reasonable. He noted that the ASAP is working hard on following the certification and CoFR process and is delving deeper into it than the Committee would have time to do. Mr. Bowersox stated that some people who are worried about the process have not been briefed. He stated that the ASAP is going to work the issue well enough and that it is not necessary to involve the NAC or the HEO Committee. Mr. Sieck observed that the transition to a new culture is going better than expected.

Mr. Bowersox thanked everyone for making the Committee meeting a success. Dr. Siegel expressed appreciation to Ms. Shawanda Robinson and Ms. Dawn Mercer for providing administrative support to the Committee.

Adjournment

Dr. Siegel adjourned the HEO Committee meeting at 4:45 PM.

**NASA ADVISORY COUNCIL
Human Exploration and Operations Committee
MEETING**

**NASA Headquarters
300 E Street SW,
Executive Conference and ViTS Center, 8Q40
Washington, DC 20546**

November 4-5, 2015

AGENDA

Wednesday, November 4

NAC HEO COMMITTEE PUBLIC MEETING

8:30 – 8:45 am	Call to Order, Welcome & Opening Remarks	Dr. Siegel & Mr. Bowersox
8:45 – 9:45	Status of the Human Exploration and Operations Mission Directorate	Mr. Greg Williams
9:45 – 10:45	Status of Exploration Systems Development	Mr. Bill Hill
10:45 – 11:00	<i>BREAK</i>	
11:00 – Noon	Status of Advanced Exploration Systems	Mr. Jason Crusan
Noon – 1:00 pm	<i>LUNCH</i>	
1:00 – 2:00	Evolvable Mars Campaign	Mr. Jason Crusan
2:00 – 2:15	<i>BREAK</i>	
2:15 – 3:30	Committee Discussion	
3:30	<i>ADJOURN</i>	

NASA ADVISORY COUNCIL
Human Exploration and Operations Committee
MEETING
NASA Headquarters
300 E Street SW,
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November 4-5, 2015

Thursday, November 5

NAC HEO COMMITTEE PUBLIC MEETING

9: 30 – 9:35	Call to Order, Welcome & Opening Remarks	Mr. Bowersox & Dr. Siegel
9:35 – 10:35	Status of International Space Station	Mr. Sam Scimemi
10:35 – 10:45	<i>BREAK</i>	
10:45 – 11:45	Status of Commercial Crew	Ms. Kathy Lueders
11:45 am – 12:45 pm	SpaceX Commercial Crew	Mr. Benjamin Reed
12:45 – 1:45	<i>LUNCH</i>	
1:45 – 2:45	Boeing Commercial Crew	Mr. John Mulholland
2:45 – 2:50	Public Comments	
2:50 – 3:00	<i>BREAK</i>	
3:00 – 4:30	Committee Discussion, Findings & Recommendations	
4:30	<i>ADJOURN</i>	

**Human Exploration and Operations Committee Membership
July 2015**

Mr. Ken Bowersox <i>Chair</i>	Former NASA astronaut and retired U.S. Navy Captain
Dr. Bette Siegel <i>Executive Secretary</i>	NASA Headquarters
Ms. Shannon Bartell	Former Director of Safety & Mission Assurance, KSC
Ms. Nancy Ann Budden	Director for Special Operations Technology, Office of the Secretary of Defense
Dr. Leroy Chiao	Former NASA Astronaut and ISS Commander
Dr. Stephen “Pat” Condon	Aerospace Consultant, former Commander of the Ogden Air Logistics Center, the Arnold Engineering Development Center, and the Air Force Armament Laboratory
Mr. Joseph Cuzzupoli	Former Assistant Apollo Program Manager, Rockwell, and manager of the Space Shuttle Orbiter Project
Mr. Tommy Holloway	Former Space Shuttle and ISS Program Manager
Mr. Lon Levin	President, SkySevenVentures
Dr. David E. Longnecker	Director, Health Care Affairs, Association of American Medical Colleges (AAMC), member of the National Academy of Sciences Institute of Medicine (IOM)
Mr. Michael Lopez-Alegria	Former NASA astronaut and retired U.S. Navy Captain, President of the Commercial Spaceflight Federation
Mr. Richard Malow	Distinguished Advisor at the Association of University for Research in Astronomy (AURA)
Mr. James Odom	Former NASA Associate Administrator for Space Station Freedom
Mr. Bob Sieck	Former Space Shuttle Launch Director
Mr. James Voss	Former NASA astronaut and retired U.S. Army Colonel, Scholar in Residence, Department of Aerospace Engineering Sciences, University of Colorado, Boulder

**Human Exploration and Operations Committee
NASA Headquarters
Washington, DC**

April 7-8, 2015

MEETING ATTENDEES

HEO Committee Members:

Bowersox, Ken, *Chair*
Siegel, Bette, *Executive Secretary*
Bartell, Shannon
Budden, Nancy Anne
Cuzzupoli, Joseph
Chiao, Lero
Condon, Stephen "Pat"
Holloway, Tommy (via telecom)
Levin, Lon
Longnecker, David
Lopez-Alegria, Michael
Malow, Richard (via telecom)
Odom, James
Sieck, Robert
Voss, James (*via telecom*)

U.S. Navy (*Ret.*)
NASA Headquarters
Aerospace Consultant
Office of the Secretary of Defense
Aerospace Consultant
Aerospace Consultant
Aerospace Consultant
Aerospace Consultant
Aerospace Consultant
SkySeven Ventures
Association of American Medical Colleges
Commercial Spaceflight Federation
Association of Universities for Research in Astronomy
Aerospace Consultant
Aerospace Consultant
University of Colorado, Boulder

NASA Attendees:

Brooks, Stacey
Carter, Kimberlyn
Crusan, Jason
Gatens, Robyn
Gates, Michele
Lueders, Kathy
Mercer, Dawn
Paget, Lee
Robinson, Shawanda
Scimemi, Sam
Thompson, Tabitha
Whitmeyer, Tom
Williams, Greg

Other Attendees:

Bednarek, Steph
Beckman, Bill
Frankel, David
Hale, Wayne
SpaceX
Boeing
PB Frankel, LLC
NASA Advisory Council

Larson, Phil	SpaceX
Mulholland, John	Boeing
Reed, Benjamin	SpaceX
Scheneweitz, Caryn	SpaceX

Telecon/WebEx Attendees:

Gerstenmaier, William	NASA Headquarters
Hill, William	NASA Headquarters
Atkinson, Loretta	NASA/Johnson Space Center
Barber, Sara	US House of Representatives
Bednarek, Stephanie	SpaceX
Berger, Eric	ARS Technica
Brandt, Peter	Interface
Branscome, Darrell	NASA consultant
Chabot, Valerie	NASA Headquarters
Ching, Mike	NASA Headquarters
Day, Brian	NASA/Ames Research Center
Dean, James	<i>Florida Today</i>
Edgington, Stacey	NASA Headquarters
Eiseman, David	NASA/Jet Propulsion Laboratory
Fisher, Tim	NASA/Johnson Space Center
Foust, Jeff	<i>Space News</i>
Galica, Carol	NASA Headquarters
Gilbert, Chris	VEConsult Independent Consultant Germany
Grondin, Yves	<i>[no affiliation]</i>
Gunderson, Sam	Blue Origin
Hambleton, Kathryn	NASA Headquarters
Karuntzos, Keith	United Launch Alliance
Kronmiller, Theodore	United Launch Alliance
Larson, Phil	SpaceX
Oesterle, Aaron	PoliSpace
Pearlman, Robert	Collectspace.com
Preston, Erin	GAO
Read, Jennifer	NASA/Johnson Space Center
Rogers, Richard	Stellar Solutions
Rummel, John	Citi Institute
Smith, Gwyn	NASA Headquarters
Smith, Marcia	Policyonline.com
Stelter, Christopher	NASA/Langley Research Center
Svitak, Amy	<i>Aviation Week</i>
Tolomeo, Raymond	NASA Headquarters
VanWychen, Kristin	GAO
White, Kamela	OMB
Zamka, George	Bigelow Aerospace
Zimmerman, Robert	Symbiotek

**Human Exploration and Operations Committee
NASA Headquarters
Washington, DC**

November 4-5, 2015

LIST OF PRESENTATION MATERIAL

- 1) NASA's Journey to Mars – HEOMD Update [Williams]
- 2) Exploration Systems Development [Hill]
- 3) HEOMD's Advanced Exploration Systems [Crusan]
- 4) Evolvable Mars Campaign and Technology Development [Crusan]
- 5) HSF Transition from ISS to cis-lunar space and ISS Status [Scimemi]
- 6) International Space Station Status [Scimemi]
- 7) CCP Status [Lueders]
- 8) SpaceX [Reed]
- 9) Boeing Commercial Crew Program [Mulholland]

Other material distributed at the meeting:

NASA's Journey to Mars - Pioneering Next Steps in Space Exploration